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## THORACIC TRAINING MODEL FOR ENDOSCOPIC CARDIAC SURGERY

### RELATED APPLICATION

This application claims priority under § 119(e) from Provisional Application No. 60/122,543, filed Mar. 2, 1999.

### FIELD OF THE INVENTION

This invention relates to a thoracic model specially designed for use in training for endoscopic cardiac surgery.

### BACKGROUND OF THE INVENTION

Traditionally, coronary artery bypass graft (CABG) surgery has been performed through a median sternotomy, which is a hole in the middle of the chest. This involves sawing the sternum, or breast bone, in half longitudinally, thereby opening the chest. A standard 30-cm median sternotomy incision has been referred to as a "manhole" incision. Beginning around 1996, cardiac surgeons began performing minimally invasive CABG.

Minimally invasive techniques use an approximately 8-cm incision "keyhole" in the fourth intercostal space, the space between the fourth and fifth ribs.

There are two primary types of minimally invasive cardiac surgery: (1) minimally invasive direct coronary artery bypass (MIDCAB), which is performed while the heart is still beating; and (2) the port-access operation, performed on an arrested heart with the use of cardiopulmonary bypass and pharmacologic cardioplegia (i.e., using potassium chloride to temporarily stop the heart from beating).

When cardiac surgery is performed on an arrested heart, blood is pumped through the body and oxygenated by an external machine, the cardiopulmonary bypass pump. This machine takes deoxygenated blood from the systemic venous system, oxygenates the blood through a semipermeable membrane, and returns this oxygenated blood to the systemic arterial circulation. This mechanism effectively bypasses the lungs, which are the normal means for oxygenating blood. In the standard CABG procedure, access to the systemic venous circulation is made through a cannula (a thin, hollow tube) inserted into the right atrium or closely related structure, such as the superior vena cava (the large vein returning blood to the heart from the head and arms). Access to the systemic arterial circulation is made through a cannula inserted into the aorta (the largest artery in the body), which carries blood away from the heart and to the body. The surgeon also cross clamps the aorta around the level of the aortic arch (near the heart).

By contrast, in minimally invasive CABG procedures, a physician accesses the systemic venous circulation through a cannula inserted into the femoral vein at the level of the groin, and the physician accesses the systemic arterial circulation through a cannula inserted into the femoral artery. The latter cannula is guided through the femoral artery superiorly, up to the aortic arch. At the tip of this aortic cannula, an endo-aortic balloon is inflated to occlude the aorta from within. This balloon inflation serves the same purpose as the aortic cross-clamping performed in standard CABG procedures.

In methods of CABG that are entirely endoscopic, the surgeon makes two or three small (e.g., 2-cm) incisions in the chest for placement of an endoscope and surgical instruments.

To become proficient with any of these surgical techniques, especially the endoscopic techniques, requires

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practice. Cadavers can sometimes be used to practice surgery, but they are in short supply and expensive. Also, because cadavers do not bleed, it is hard to tell if surgical anastomoses have been performed successfully. There is thus a need for alternative ways to become proficient in the endoscopic cardiac surgery.

### SUMMARY OF THE INVENTION

There is thus provided a surgical model for use with training, for cardiac surgery using endoscopic techniques. The model includes a thorax having anatomically correct representations of a plurality of ribs, at such that endoscopic instruments can be inserted between the ribs (i.e., in the intercostal spaces) during use of the model. An anatomically correct representation of a heart is located in an anatomically correct position in the thorax and is removably connected to the model. The heart has at least one major coronary artery on which surgical training can be performed during use of the model. A sternum is removably fastened to the anterior aspect of the thorax of the model, the sternum having a representation of at least one internal mammary artery on a posterior surface of the sternum.

In a further embodiment, the model has a removable skin enclosing or surrounding the model. Further, the skin advantageously comprises landmarks, including at least one of a nipple or an umbilicus. Moreover, a further embodiment comprises a fluid system in fluid communication with the heart and providing pressurized fluid to the coronary arteries so that cutting, the arteries simulates bleeding when the pressurized fluid effuses from the coronary artery. The fluid system is preferably also in fluid communication with the internal mammary arteries and provides pressurized fluid to the internal mammary arteries so that cutting the internal mammary arteries simulates bleeding when the pressurized fluid effuses from the internal mammary artery. Additionally, in certain embodiments there are representations of a pair of lungs, collapsed lungs in some embodiments, on opposing sides of the heart. Moreover, at least one of the arteries can taper in diameter, reducing in size toward its distal end.

The arteries are also preferably formed of a selected size, and formed of a selected material, selected to simulate the physical characteristics sensed by a surgeon performing endoscopic bypass surgery on a live person. Advantageously, there is a space between the posterior surface of the sternum and the anterior surface of the heart of up to about 3 inches when the heart is empty of blood.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a frontal cut-away view of the thoracic model.

FIG. 2 is a schematic frontal view of one embodiment of the model heart.

FIG. 3 is a schematic side view of one embodiment of the model heart and an IV bag assembly.

FIG. 4 is a schematic drawing of one embodiment of the internal mammary artery assembly.

FIG. 5 is a frontal exploded view of the thoracic model, with sternum and endoscopic instruments.

FIG. 6 is a close-up, cross-sectional side view of one embodiment of the model coronary artery and heart wall.

FIG. 7 is a cross-sectional side view of one embodiment of the thoracic model and fluid assembly.

FIG. 8 is an axial cross-sectional view of one embodiment of the thoracic model.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In describing the thoracic model, the terms "heart," "artery," "skin," and the like are used in many instances